Cleaner and efficient technology interventions in small and medium scale industries in India, using biomass gasifier systems

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Agency for Non conventional Energy and Rural Technology
P B No. 1094, Kesavadasapuram,
Thiruvananthapuram, 695004 Kerala

Tel: 0471-440121,440122
Fax: 0471-449854

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PROJECT BRIEF

PROJECT TITLE	Cleaner and efficient technology interventions in small and medium scale industries in India, using biomass gasifier systems
REQUESTING COUNTRY	India
PROJECT TYPE	Full Project
DURATION	5 years
GEF IMPLEMENTING AGENCY	UNDP
EXECUTING AGENCY	Agency for Non-conventional Energy and Rural Technology (ANERT)
TECHNICAL SUPPORT AGENCY	Tata Energy Research Institute (TERI)
ELIGIBILITY	India ratified the UNFCC on November 1993
GEF FOCAL AREA	Climate Change
GEF PROGRAMME FRAMEWORK	Operation Programme 5

SUMMARY

A major portion of energy is consumed by many small-and medium-scale industries to meet their low-grade thermal energy requirements for water heating, steam generation and hot air generation. Reduction in the consumption of fossil fuels and utilization of firewood more efficiently are both priorities of the Government of India. India is an agricultural economy and there is huge potential for the use of agricultural, agro-industrial residues (excluding bagasse), and forestry residues which are produced in large quantities. This valuable resource can be used to advantage in gasification to meet the energy demand more effectively. However, many constraints such as a lack of awareness among user groups, the problem of gasifier system integration with the process, high up front costs, lack of institutional arrangements for after-sales service and suitable financing/credit mechanism prevent the large-scale penetration of this technology

The project aims at removing these barriers by developing and demonstrating gasifier-based packages for selected target industries, which can later be replicated in other industries. The project aims at developing and demonstrating these systems by setting up institutional linkages for ESCOs, manufacturing, financing, marketing and after-sales service mechanisms.

FINANCING AND LEVERAGE

	Million US $	Percent
Total project cost	11.32	100
GEF Financing	5.36	47.35
Co-financing		
MNES. GoI	1.21	10.69
State government	0.6	5 3
Users/beneficiaries	1.14	10.07
Bilaterals/loan	3.00	26.5

1.1 SMES sector

The small-scale industries occupy an important place in the country's economy India has more than 3 million small-scale industries in the organized sector and about 15 million enterprises in the unorganized sector. These units account for about 40% of the total industrial output in the country and in terms of employment generation this sector is next only to agriculture contributing an estimated 14% to the GDP. The total expenditure per enterprise on energy (fuel and electricity) increased by about 200% between the two reference years (1990-1995). The expenditure on fuel and electricity increased more than proportionately in comparison to the total inputs. As per the estimate, of the energy consuming enterprises 28% uses firewood as their source of energy while about 8% of the enterprises use charcoal to meet their energy needs. A large population of small enterprises uses fossil fuel as the main source of energy. In recent years, the prices of energy, both thermal and electrical, have been increasing steadily. For example, diesel oil prices have increased to Rs. 17.05/litre (2001) from Rs.7.95/litre (January 1997). Similarly, other petroleum fuels have also registered a steep increase in prices due to the soaring international prices of crude oil. The electricity tariff for industrial customers is also generally much higher compared to agricultural customers, resulting in a cross subsidy and with various regulatory mechanisms coming into force, industrial customers may have to pay even higher rates. Also, concessional tariffs provided initially to encourage small industry are coming to an end, resulting in a sudden, heavy burden on such industries. All this, combined with the current sluggishness in the economy, is affecting the small and tiny sector in a big way. The main issues related to the SMEs sector are:

- Technological stagnation/obsolescence both in machinery and processes used
- Inadequate availability of credit
- Managerial, financial and marketing weaknesses
- Cumbersome rules, regulations and procedural tangles

1.2 Biomass Energy

India as an agricultural economy has a large exploitable potential for power generation from agricultural, agro-industrial residues (excluding bagasse), and forestry residues which have been estimated conservatively at 16,000 MW. To tap this large potential a National Biomass Gasifier Programme for mechanical, electrical, thermal heating/cooking

applications has been launched by the Ministry of Non-conventional Energy Sources (MNES). Under the scheme a target of 10 MW equivalent biomass gasifiers with an annual outlay of Rs 1 crore has been envisaged. Greater emphasis has been given to village electrification and captive power generation projects. However, the technology has huge potential for meeting the process heat requirements of small and medium industries.

In the 10th Five Year Plan the Ministry of Non-conventional Energy Sources is giving a thrust to oil replacement initiatives for thermal applications. The major focus of such an initiative is on small and medium industries where a large number of oil-fired boilers, thermo packs, driers, hot air generators, ovens, and furnaces are in use.

1.3 Alternative energy technology

Though prices of fossil fuels such as diesel have increased several folds in the last decade, those of biomass have not increased in the same proportion. In the current situation, the most promising energy option for small and medium enterprises, reeling under high-energy costs, is biomass and its gasification technology can offer the advantages of commercial fuels such as LPG, diesel and kerosene, but at much lower costs. An additional advantage of replacing fossil fuel with biomass will be major reductions in GHG emissions.

Most biomass-consuming industries currently rely upon unsustainable sources with environmental implications such as deforestation, land degradation etc. An estimated 20 million tons of biomass is also used in traditional and rural enterprises. A survey of some biomass-using enterprises and available data show that the end-use efficiencies of devices used in such enterprises is also quite low. A partial list of biomass-using enterprises is shown in Table 1.

Though the bio-resource base of India is substantial, its contribution to useful energy is low. An indirect consequence of the low-energy use efficiency is that carbon emissions are high. The ratios of carbon content to calorific value of several fuels, including biofuels and bio-derived fuels, but that of hydrogen-rich fuels such as natural gas is comparable. The carbon emissions per unit of 'useful energy', which takes into account the device efficiency. In case of traditionally used biofuels emit nearly ten times more carbon into the atmosphere per unit of useful energy. One might argue that, since biofuels do not contribute to 'net' carbon emissions, the issue of end use energy efficiency is not very important. But

considering that biomass is harvested unsustainably in most developing countries and that the forest cover in these countries is substantially lower than desired levels, more efficient utilization of biomass will definitely enhance the 'sink' effect of forests. Seen from this angle, climate change projects aimed at biofuel conservation should get at least as much importance as afforestation projects.

A second issue related to biomass combustion in traditional devices is concerned with products of incomplete combustion (PIC), chiefly carbon monoxide, methane, total non-methane organic compounds (TNMOC) and N_2O. These greenhouse gases have higher global warming potentials (GWPs) and it has been shown that their CO_2 equivalent contribution is nearly the same as the actual CO_2 emitted. Results of a study conducted for 28 stove-fuel combinations in India clearly establish that the currently practiced biomass cycles are not GHG-neutral. In fact the study highlights the win-win situation achievable by promoting use of 'modern' biofuels such as biogas and producer gas.

A gasifier is a potentially viable system for significant (50%) fuel savings as already demonstrated by TERI and others in many small and medium industries. The adoption of a gasifier technology in many of these processes also leads to improved productivity and quality of the end product, because of better process control, which was not possible with the direct combustion route. This further improves the economic viability of the operation. The intervention in a biomass-consuming industry would save about 50% of the present consumption, which will result in an increase in the carbon sink

Table 1. Partial list of various small-scale industries surveyed for adoption

Name of Industry	No of units	State
Silk reeling	60,000	A P, Karnataka
Dyeing (cotton and silk)		A P, Karnataka
Puffed rice making	50,000	Karnataka
Crumb rubber	60	Kerala
Tapioca making	500	Tamil Nadu
Bakeries		All over India
Hotels		All over India
Lead recovery from used batteries	200	Karnataka (Bangalore)
Wire enamelling unit		Karnataka
Tobacco curing	30,000	Karnataka
Lime kilns	50	U P, Himachal Pradesh
Mini-cement plants	200	U P, Himachal Pradesh
Gur making	2,000	U P
Tea drying		Kerala, Tamil Nadu
Brick tile drying		Kerala
Beedi manufacture		Kerala
Khoya making		Rajasthan (Bundelkhand)
Small cardamom		Kerala
Coffee curing		Karnataka
Food processing		All over India
Carbon dioxide manufacture		Gujarat
Copra drying		Kerala, Tamil Nadu

1.4 Target industries

Out of the small-scale enterprises the following industries. situated in southern India (Kerala. Tamil Nadu. Karnataka and Andhra Pradesh) have been selected for possible intervention.

- Crumb rubber
- Tea production
- Silk reeling
- Textile dyeing
- Tobacco curing

These industries have been selected mainly because they operate in the geographical by similar clusters and their fuel costs are a significant part of their total production cost.

Crumb rubber

India is the third largest producer of rubber after Thailand and Indonesia in the world with a total annual production of 629000 MT (in 2000) Rubber cultivation in India was traditionally confined to a narrow belt extending from Kanyakumari district of Tamil Nadu in the South, to Dakshin Kannada and Kodagu districts of Karnataka state in the north, and lying in general west of the Western Ghats and parallel to them for approximately 400 km. The soils in this rubber tract are highly weathered and consist mostly of laterite and lateritic types Red and alluvial soils are also seen in some areas.

The main crop from the rubber tree is latex, a milky white dispersion of rubber in water. which is harvested by the process of tapping. The latex that flows out from the rubber trees on tapping is channeled into a container attached to them. The important forms in which the crop from rubber plantations can be processed and marketed, are the following

1. Sheet rubbers
2. Crepe rubbers
3. Preserved field latex and latex concentrates
4. Block rubber.

All the new methods of processing thus evolved can handle coagulum produced from latex and all forms of scrap rubber and involve practically the same operating units mentioned below:

Size reduction
De-watering
Dirt removal
Drying
Baling and
Grading

Drying

Drying of the crumbs, pellets or granules produced in all the new processes for the manufacture of block rubbers, is carried out at a temperature of about 100°C. The drying time depends upon the size of the particles. Usually 4 to 8 hours will be required for complete drying. The tunnel dryer commonly used for this purpose consists of a movable tray fitted under a stationary hood, which contains an air circulating duct fan and heat exchanger. The drying temperature is regulated so that the temperature never exceeds 110°C to prevent degradation and discoluration of the product. The dried crumbs, pellets or granules are pressed when they are below 50°C in a hydraulic press. 30 to 50 tonne pressure is generally used for the purpose. Bales, preferably 25 kg are generally prepared.

The block rubber units generate hot air either by burning diesel or electricity. To encourage such units the Kerala government had provided subsidized electricity @ Rs 0.50/kWh for the first five years of operation to these units. The period of availing subsidized electricity has expired for most of these units and they will have to pay the normal electricity tariff @ Rs 2.60/kWh. Now, the industry is looking for new technologies such as gasifiers to reduce their production cost.

Silk reeling

Silk holds a unique place in the textile world and is regarded as the Queen of Textiles. India is a traditional sericulture country and ranks only next to China in silk production. India produced around 14,500 metric tons of natural silk during the year 1993-94. Majority of the silk is reeled either in charkha or in the cottage basin ovens. At present there are about 35,000

charkha basins and 26.000 cottage basin registered units in different states. Firewood is mainly used by the cottage basin whereas charkha units use local available loose biomass (such as groundnut shell. tamarind husk. rice husk. coffee beans. etc.). It is estimated that about 1.05.000 tons of loose biomass and 1.20.000 tons of fuelwood are consumed every year for the production of silk yarn with an overall useful efficiency of 12-15%. Over the years. the profitability of the Indian silk reeling industry has been affected due to cheaper raw silk imports and high cocoon prices. both of which factors are beyond the control of reelers. In addition overall productivity of the sector is low. because no systematic attempts were ever made to upgrade technology, consume energy or recover by products.

Tea industry

India is the largest tea producing country, in the world. The annual production of black tea was about 0.87 million tonnes during the year 1998. About 4,32.000 hectares of land is under tea cultivation. The tea industries are spread over both in northern region and southern region. In southern part of India. tea industries are spread over Tamil Nadu and Kerala. About 6000 Kcal of thermal energy is required for drying 1 Kg of tea. Tea industry uses a mixture of fuel. for drying process. Intervention of biomass gasification technology will help in reduction of carbon emissions in the sector.

Tobacco curing

Tobacco curing industries are spread over Karnataka and Andhra Pradesh of Southern part of India. About 1,20,000 hectares of land is under tobacco cultivation. There are several small-scale units in the field to dry the tobacco. They operate only in the season. for about a period of two months in a year. Installation of several small-scale gasifiers for tobacco curing industries will save an enormous amount of tree, been cut every year.

2.0 RATIONALE AND OBJECTIVES OF THE PROJECT

2.1 Objectives

The logical framework for the project is given in Annexure-B. The main objective of the project is to reduce CO_2 emissions through the promotion of biomass-based gasifier systems for various thermal applications in small and medium scale industries. The immediate objectives of the project are:

1. To provide a biomass gasifier-based technology package for a selected set of industries located in clusters to reduce their energy cost either by increasing the combustion efficiency or by fuel shifting, and
2. To remove barriers in the way of large-scale adoption and commercialization of the technology.
3. To establish energy service companies (ESCOs) for sustaining an after-sales service network.

The project has been prepared consistent with the goals and guidelines of the GEF Operational Program 5 **"Removal of barriers to energy efficiency and energy conservation"**

2.2 Proposed intervention for carbon emission reduction

The proposed project has been initiated by the Tata Energy Research Institute (TERI) based on past ten years successful experiences over the past 10 years in demonstrating the gasifier technology for thermal applications such as CO_2 production, silk reeling, dyeing, crop drying, large scale cooking, steam production etc., in collaboration with the Agency for Non-conventional Energy and Rural Technology (ANERT) state nodal agency of Kerala. The proposed intervention will have a significant impact on the environment, locally and globally. The institutional arrangement is given in Section 5.

2.3 Scientific and technical basis for assistance for proposed project

There is significant potential to improve energy efficiency in biomass-consuming industries as well as replacing the present fossil fuel consumption for heat generation purposes in many small and medium scale industries. The proposed project focuses on providing a gasifier-based package for selected industries in small and medium industries, which can later be easily taken to other potential industries. A biomass gasifier package has following advantages:

- Replacement of fossil fuels and non-sustainable fuelwood with sustainable biomass (crop residues, mill residues etc.) leading to GHG emissions reduction.
- Creation of new opportunities for employment and avenues for income generation (biomass supply chain, after sales service network etc.)
- Reduction of petroleum imports

- Better quality of end-produce. which would result in domestic industry being more competitive globally
- Better working environment for workers. less expenses on occupational health-related problems.

2.4 Barriers to biomass gasification technology

Though the gasifier technology has large potential for replacing fossil fuel in small and medium industries, government programmes have largely centered around decentralized power generation applications. This project aims for the gasifier meeting the thermal energy requirements of many small and medium scale industries. However, there are three major barriers in the way of greater market penetration of such systems in these industries.

Technical barriers

The induction of a gasifier system into a specific industry is not a simple add-on job. Experience shows that the process and equipment used in the SSI may have to be modified to some extent to accommodate the gasifier. This integration requires system engineering inputs from expert groups and some trial runs. Many small, trivial matters related to operation and maintenance procedures will have to be sorted out during this period. Also, a certain amount of fine-tuning might be required in the first few months of installation. These will require the presence of both the manufacturer and technology-provider on the site. The costs of such fine tuning and technology acclimatization will have to be borne by the project and can not be included in the initial product costing. Once the package is proven by demonstrations in a few clusters, adequate attention can be paid to the financing and marketing aspects.

Financial barriers

Both the small industry user and conventional financing institutions hesitate to invest in new technologies such as gasification. The new products/technology are perceived as somewhat risky and there will be an initial period in which the user gets acquainted with the new technology of gasification. Hence a separate credit line with flexible arrangements at user's doorstep is required to help in mainstreaming gasifier thermal applications.

Institutional barriers

The lack of in-house capabilities of small and medium industries in solving operational and maintenance problems poses a significant barrier in promotion of the technology. Hence, the proposed project aims to develop ESCOs for enhancing this capability. The project will aim to establish the appropriate institution mechanism for achieving sustainability.

2.5 Linkage to local, national and global development objectives

The direct beneficiaries of this project will be the small and medium scale industries in India which will achieve production cost reductions through increased energy efficiency or by reduced energy cost, thereby increasing profits.

About 60 crumb rubber units, 350 tea processing units, 5000 silk-reeling units (cottage basins), 1000 textile dyeing units and 1,00,000 tobacco curing units will be benefitted. A potential list of small-scale industries, which can be benefited, with adoption of a biomass gasifier is given in Table 1.

The project will create new business opportunities for various players in the complete commercial chain for manufacturers, marketer, ESCOs, biomass suppliers, farmers, NGO's, local banks and financial institutes etc. In all about ten entrepreneurs will be selected and trained in each of the proposed clusters. The project will also strengthen the capacity of the government programme and policy. The draft Tenth Five-year Plan for biomass programme of ministry has envisaged for gasifier promotion in efforts to replace petroleum products for thermal application in the industry. The major focus of such an initiative will be on small and medium industries.

On the global front, the project will facilitate a CO_2-neutral path and also have immense potential for replication in other third world countries.

3.0 PROJECT ACTIVITIES AND EXPECTED RESULTS

The project planning matrix is given in Annexure C. The major activities of the project are as follows:

Activity 1: Standardization of technology package

Objectives of Activity 1

- Survey and field interaction to assess the current energy use pattern of selected set of industries
- Detailed energy audit of selected unit to assess the process parameters
- To arrive the system configuration along with accessories
- To develop a set of detailed system configuration specifications along with detailed engineering drawings

Description of Activity 1.

A preliminary survey will be carried out in the selected potential clusters to get information about the size and capacity of the units and data related to the present energy consumption pattern. Based on the preliminary survey, a detailed energy audit will be carried out in the representative sample units in each of the selected industries to obtain the existing energy usage pattern along with other process parameters. The alternative system configuration, which includes the gasifier and balance of system, will be decided based on the energy data. It is planned to take inputs about the alternative system design with a group of experts and engineering consultants through consultative process. Finally a set of detailed system specifications along with the drawing will be prepared for each set of interventions.

Activity 2: System integration, demonstration and field testing

Objectives of Activity 2.

- To integrate the gasifier with the existing processes
- To demonstrate the technical and economical claims of the alternative system

Description of Activity 2

The induction of a gasifier system into a specific process is not simple and straightforward job. TERI's past experience shows that the process and equipment used in the SSI may have to be modified to some extent to accommodate the gasifier to exploit its full potential. This integration requires system engineering and process experts inputs along with the alternative technology supplier. The proposed system will be of field trial and tested at the selected site. Potential enthusiastic users will be identified for initial system installation and demonstration. The number of users in each selected cluster will be chosen according to the volume and geographical spread of the particular industry. To a large extent the selection will

be considered based on the extent of financial commitment by the individual user towards the project cost.

At the local level suitable manufacturers will be identified and necessary training will be provided by TERI. Technical support will be provided to develop the infrastructure facility for fabrication of the system along with the accessories. The supply of all the related hardware including the operation and maintenance for one year will be on part of the gasifier's supplier. After initial successful trial runs the alternative system will be field tested on regular operation and data related to the technical operation of system along with the economics of operation will be collected.

Activity 3: Removal of financial barriers and creation of investment risk fund

Objectives of Activity 3:

The main objective of the activity will be to overcome financial barriers and to facilitate the large-scale penetration of the gasifier technology by creation of a separate line of credit. The fund will provide the initial capital for acquiring the gasifier systems on flexible terms and conditions. The fund will also offset the risk involved with the technology especially during the initial stages of penetration.

The project is focusing on cleaner and more efficient alternative technology interventions, in SMEs. There are risks including capital investment for the first few systems, resistance to user participation, establishment of biomass supply, disinterest of manufacturer, ESCOs and financiers. Risks foreseen during the implementation of the project also include level of support from the local agencies, industrial associations and NGOs.

ANERT and TERI will carry out the risk mitigation measures jointly, to tackle the managerial and technological risks. To implement the project and overcome risk factors the following activities have been identified.

Guidelines for operation of revolving fund

The partial capital investment, part of the co-financing arrangement on the initial systems of each cluster, will be collected periodically according to a prefixed rate of return and capital investment. The collected amount will be used to sustain the project through a financing committee involving the local agencies and stakeholders. The revolving fund will ensure the installation operation and maintenance of the systems, through the marketers and ESCOs

Develop recovery guidelines and mechanism

Guidelines will be developed for an effective recovering mechanism. All the stakeholders will be involved in developing the recovery guidelines. The committee formed for financing the revolving fund will be engaged in forming the recovery guidelines The guidelines will take in to account capital investment and rate of return, system life cycle etc.

Capital equipment finances

Due to the nature of the project, risks are likely to be faced from the marketers and ESCOs for the capital investment. To mitigate this situation, a capital equipment financing will support the system fabrication and installation cost including integration of the new system with the existing conventional one. Capital equipment financing has to be provided to cover all selected sectors of applications. The capital equipment financing mechanism will be arrived at based on the system cost, volume of market.

Monitoring of the revolving fund

A close, regular and periodic monitoring of the revolving fund will be carried out, while executing the project. The finance committee will review the return and monitor the flow of the revolving fund. This activity will ensure the sustainability of the project, even after the five-year period of the active GEF project. The agency of the local government ANERT will play a major role in monitoring and investing the revolving fund in accordance with the finance committee. The revolving fund will be invested to each of the selected clusters in suitable proportions.

Activity 4: Information dissemination

Objectives of Activity 4

To develop an information package. which will include the detailed technical design and specifications, costs, benefits, sources of suppliers. finance etc.

To disseminate information about the new technology through demonstrations. workshops, technical reports and mass media.

Description of Activity 4

In response to the awareness barrier. an information package will be developed. Awareness-creation programmes will focus on users, technological backup for marketers and managerial support to the ESCOs.

Awareness creation

Awareness creation among the user is most important step in the process of implementing the project. The awareness creation will be achieved through workshops, conferences, documentary films, brochures and booklets, which highlight the features of the new technology and its economic viability and other benefits.

Market promotion

Books explaining the fabrication details along with specifications will be prepared to support the marketers. Training programmes will be organized for the manufacturer to fabricate the systems with the required quality standard. Training programmes will cover each selected sector, on system integration to obtain higher efficiency, clean environment and quality product. The manufacturers training programmes will include the safety aspects of the system operation, which is a very important aspect of marketing the product. Facilitating programmes will be conducted for/by the marketer to establish a sustainable market base.

Field visit to sites

In each of the clusters a few of the systems will be integrated with alternative technology. As a part of the information dissemination programme field visits will be organized to other users and the stakeholders in each cluster. for visualizing the benefit of the technology in field conditions. Field visits will encourage and enable the stakeholders to actively involve in promotion measures for wide dissemination in each cluster.

Activity 5: Enabling activities

Objectives of activity 5

The project will create a favorable environment for the emergence of ESCOs to provide after-sales technical support, supply of required biomass to the users. The ESCOs will provide these services on a cost-recovery basis through negotiated contracts

Description of Activity 5

A gasifier has huge potential in many cottage and small industries such as silk reeling, khoya making, tobacco curing and cardamom curing, but these industries do not have the technical capacity to absorb it. It would therefore be easy to penetrate these industries by creating ESCOs at local cluster level. The objective of these ESCOs will be to install the gasifier systems under BOLT/BOOT/BOO principles. To facilitate the formation and operation of ESCOs, it is necessary to make available them working capital at attractive terms and conditions. This would help them to establish the necessary infrastructure at the field level. It is expected that a minimum of 20 ESCOs will be required over next 5 years. The project will form guidelines to provide finance to ESCOs.

Activity 6: Enhanced institutional and financial capability

Objectives of Activity 6

- To create institutional arrangements for implementation of the project
- To strengthen the capacity of various stakeholders through specific design training programmes, workshops etc.
- To establish infrastructure for manufacturing, marketing, after-sales service, biomass supply etc.

Description of Activity 6

It is proposed that a separate project-monitoring cell will be created at ANERT (the main implementation agency). A project steering committee will be constituted at the state level. A technical support group will be formed at TERI to support the project in various technical-related decisions and advice. The project will cover the learning curve costs and other transaction costs through workshops, training and demonstrations. The project will establish a supply chain mechanism, after-sales service and biomass supply network. The project will strengthen the banks to be able to support investments and appraisal of such investment proposals.

4.0 RISKS AND SUSTAINABILITY

The proposed project is trying to promote a renewable energy technology in rural small-scale industries of India, which are still using traditional age-old inefficient technologies and systems. There are risks associated with it. These risks are kept in mind while formulating the strategy of this project document to minimize them and to implement a strategy to overcome them while executing the project. The possible risks and measures to keep them at low level or overcome them are discussed below.

4.1 Risks

Non-participation of local NGOs, industry associations, governmental agencies:

The proposed project is trying to promote gasifier technologies, which has been attempted over the years with limited success even with subsidy-oriented programmes. In order to ensure participation, local governmental agencies (state nodal agency) have been involved right from the conception and formulation of a proposed project through a series of meetings and workshops. Also, the formation project monitoring/coordination committee with representatives of all stakeholders will ensure smooth execution of the project activities. Local industrial associations, committees will be consulted with while identifying potential clusters for intervention of the gasifier technology in the target region and also while developing an appropriate user-friendly technological package for identified gasifier applications. A series of meetings, awareness workshops are planned to sensitize the target industrial cluster to gasifier technology.

Poor or no recovery of gasifier system cost/investment

This is a common risk perceived with the promotion of any new technology or system in rural parts of India specially with unproven technology with which user is not familiar. The user may have doubts about its benefits and the reliability of improved performance with regard to the repayment of incremental investment through monetary savings. In order to overcome this risk the project envisages to formulate proper ESCOs which will provide much-needed after-sales service to target groups in order to ensure proper functioning of the commissioned gasifier system which in turn will increase benefits to the user thus enabling him to repay investments and also help in building confidence in the new technology The project also tries to overcome the barrier of repayment by formulating a suitable financial mechanism to help the user invest in gasifier systems with attractive repayment options

without compromising the sustainability of the long-term promotion of gasifier technology in the target group.

Non acceptability of the technological intervention

The target group is rural small-scale enterprises using traditional technologies which are known to be inefficient but are still being followed due to an inertia also partially due to the inability to invest in the development of efficient and eco-friendly technological interventions on their own. This project tries to develop such efficient and eco-friendly technologies for such low capacity end-users. In order to overcome the risk of unacceptability, the project plans to involve local industries associations, users, and design consultants during the process of product development. The design review workshop planned under the project will help in evolving an appropriate user-friendly technological package, which will have better chances of acceptance and hence large-scale penetration in the field.

Inferior quality of systems·

While promoting the new technology in the field there is always risk of inferior system quality which is critical during the initial phase as it may spoil the name of the technology and make the promotion very difficult. In order to overcome this risk the manufacturer will be selected through strict scrutiny and will be trained to produce a good quality product. Quality control of the systems manufactured will be done meticulously and it is planned to develop a suitable quality-control mechanism for long term successful promotion of gasifier systems in the field.

Poor and unreliable performance of the system:

A poorly performing product like one of inferior quality will result in poor penetration of the system in the market. The project plans to monitor the system performance to its quantify benefits and arrive at the techno-economic feasibility of the technological intervention. Also an effort to develop capacity building of the target industrial group will be carried out to train them to operate the system properly. The planned ESCO in the project will also play a vital role in achieving desired system performance by providing after-sales service support to ensure smooth and reliable operation of the system. Also quality control in manufacturing will help in minimizing this risk.

4.2 Sustainability

So far the major thrust of governmental programmes to promote gasifier systems is through subsidy driven programmes, though recently there is a trend to shift from capital subsidy to interest subsidy. Also there is more stress on gasifier-based power generation than on thermal gasifier applications. The present project envisages promoting gasifier systems for a variety of thermal applications in the rural small-scale industry cluster which traditionally and potentially a biomass-using industry. (Currently using other fossil fuel to meet thermal energy needs but are willing to shift to biomass if found techno-economically feasible).

The major thrust of the proposed project is to overcome all possible barriers in promotion of gasifier systems in the field viz. technological, financial, marketing network and after-sales service. This will not only help in successful promotion of technology in the field but will act as a model for other gasifier applications in India and abroad.

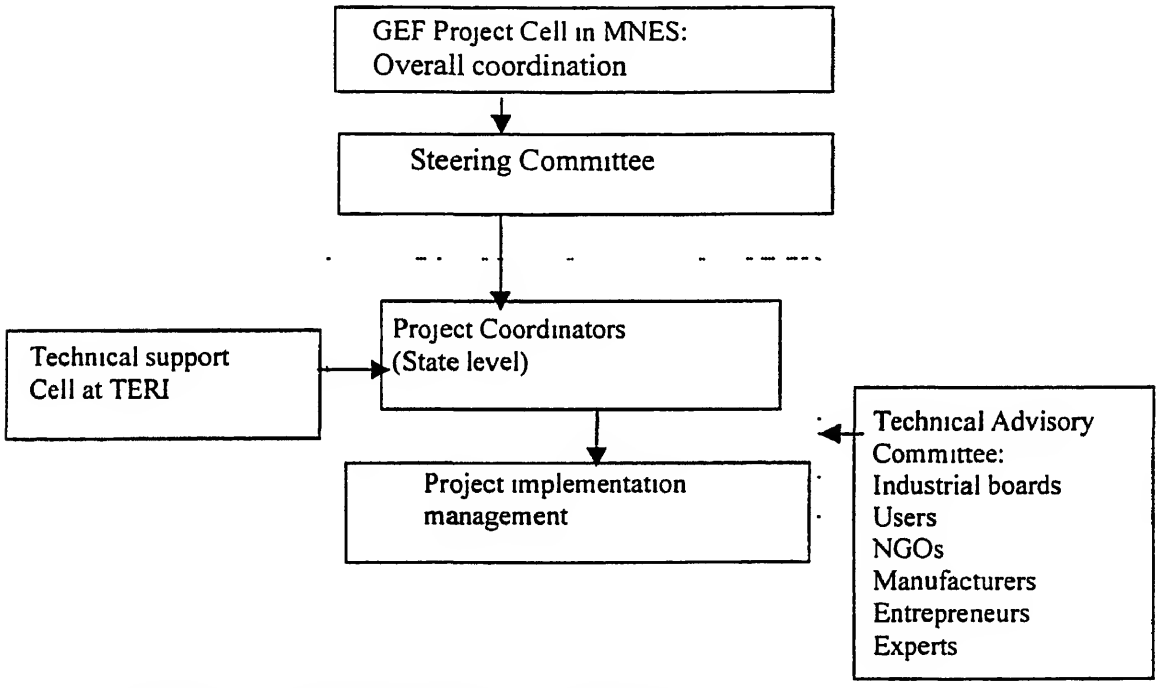
The involvement of various stakeholders and organization of a design review workshop will help in evolving an energy efficient and eco-friendly technological gasifier system package which will have better prospects of acceptability due to user-friendliness. Quality control during system manufacturing and capacity building of the user community for system operation as well as after-sales service by established ESCOs will ensure smooth and reliable system operation in the field. Development of a suitable financing mechanism, ESCOs and a marketing network will help not only in achieving large-scale penetration of gasifier systems in target groups but will also act as a model for the promotion of gasifier and other RETS in other parts of India for a variety of applications in a self-sustainable manner.

5.0 Stakeholder Participation and Implementation Arrangements

The project has been formulated to support participatory mechanisms among targeted stakeholders. The project has been developed in consultation with all key stakeholders such as apex bodies of target industries, entrepreneurs, state nodal agencies, concerned departments/ministries, financial institutions and banks Since the project will operate in many states, the MNES will execute the project. The UNDP country office will be responsible for the overall local supervision of the project progress and achievement. ANERT, as an executing agency for the project, will create a project monitoring cell.

A project steering committee will be established with representatives from all the relevant concerned ministries, state agencies, UNDP, user groups and industrial associations A technical support group at TERI will assist the PMU in all technical issues and for developing the package for respective industries. A full time project manager will be appointed for the entire project period and will be responsible for project implementation. The proposed institutional arrangement is given in Figure 1.

Figure 1 Project implementation arrangement



6.0 INCREMENTAL COSTS AND PROJECT FINANCING

The biomass-based gasifier system package proposed under the project is capable of meeting the energy needs of target sectors at a much lower economic cost compared with the system currently in use. The alternative systems are economically viable on a life-cycle cost basis besides the additional environment benefits. However, many barriers as identified in the proposal need to be overcome for successful implementation and dissemination of these systems. The cost of overcoming these barriers as identified in the proposal becomes the incremental cost, and support from GEF is requested for this area.

Baseline Scenario

In the project boundary, the current baseline scenario for different sets of target industries is given in Table 2 and wherever more than one type of fuel is used, the baseline scenario is considered on the basis of the population sample. Under the project boundary as stated above, the current baseline in the target industries would continue to use either conventional fuels, i.e. diesel/electricity or firewood from unsustainable route leading to net GHG emissions.

Table 2 Baseline scenario for different sets of target industries

Target Industries	Present fuel consumption	Baseline
Crumb rubber	Diesel/electricity	Diesel
Silk reeling	Wood	Wood
Textile dyeing	Wood/diesel	Wood
Tea	Wood/leco/LPG	Wood
Tobacoo curing	Wood/coal	Wood

C-emission abatement

The proposed project focuses interventions using energy-efficient and environmentally sound technologies. The geographical area selected to start with, is the southern part of India covering the four states Kerala, Tamil Nadu, Andhra Pradesh and Karnataka The project aims to provide all the thermal energy requirements of the target set of industries through gasifier technology based on sustainable biomass resources thereby leading to GHG emission reductions Under the project case, biomass gasifiers utilizing agricultural residue briquettes or locally grown wood will be installed. It is proposed that about 24 such system for crumb rubber, 300 for silk reeling, 50 for textile dyeing and 30 for tea units will be installed. The carbon mitigation potential under each of the interventions is given in Table 3. In the project boundary, it is estimated to mitigate 53689 tonnes of carbon per annum. By replication of the technology the total potential of carbon mitigation in the selected clusters will be about 0.54 million tons per annum

Table 3 C-mitigation potential

Activity	Annual C-emission avoided (tC)	Mitigation potential per system in 15 y (tC)	Total mitigation potential in proposed intervention in tC	Total mitigation potential (mtC)
Rubber	53.10	796.50	19116.00	0.05
Tea	233.80	3507.00	105210.00	1.23
Silk reeling	11.24	168.60	50580.00	0.98
Textile dyeing	149.90	2248.50	112425.00	2.25
Tobacco	2.40	36.00	18000.00	3.60
Mitigation potential	450.44	6756.60	305331.00	8.10

Incremental Cost

For each of proposed intervention, the baseline costs are estimated (see Table 4) which include the capital cost, cost of fuel, operation and maintenance. For the crumb rubber case, over the project lifetime, this would come to approximate US $5.63 m. For the silk reeling sector where forest wood has been utilized, costs come to about US $2.46 m. For textile dyeing costs would be about US $5.48 m. For tea processing units, US $5.66 m and for tobacco curing, US $1.86 m.

The life cycle costs under each alternative interventions is estimated (see Table 4). For the crumb rubber case, over the project lifetime, this would come to US $4.42 m. For silk reeling sector costs would comes to about US $2.14 m. For textile dyeing would costs US $4.55 m. For tea processing units would costs US $ 4.72 m and for tobacco curing comes to about US $2.14 m. The total capital costs for baseline case include the cost of conventional system is US $26 m (diesel system or wood fired furnace) whereas for alternate scenario is US $6.5 m (gasifier based system). However, the total life cycle costs for alternative project case is low compared with baseline option.

Table 4 Incremental Cost of each intervention (US$ million)

Target industries	Baseline scenario (B)	Alternative scenario (A)	Incremental cost (A-B)
Rubber			
Capital	0.05	1.30	1.25
O&M cost	0.58	1.55	0.97
Fuel	5.00	1.57	-3.43
Total	5.63	4.42	-1.21
Silk			
Capital	0.46	0.64	0.18
O&M cost	0.04	0.29	0.25
Fuel	1.97	1.21	-0.75
Total	2.46	2.14	-0.32
Textile dyeing			
Capital	0.46	1.64	1.17
O&M cost	0.54	0.44	-0.10
Fuel	4.48	2.47	-2.01
Total	5.48	4.55	-0.94
Tea			
Capital	0.82	1.71	0.89
O&M cost	0.12	0.30	0.18
Fuel	4.72	2.71	-2.01
Total	5.66	4.72	-0.94
Tobacco curing			
Capital	0.81	1.17	0.36
O&M cost	0.13	0.39	0.25
Fuel	0.91	0.58	-0.33
Total	1.86	2.14	0.28

Replication potential

The proposed project focuses on intervention of energy efficient and environmentally sound technologies The geographical area selected to start with is the southern part of India covering the four states Kerala, Tamil Nadu, Andhra Pradesh and Karnataka. Successful implementation of this project will lead to a large level replication of the technology, in other parts of the country and for several other potential small and medium scale industries.

7.0 MONITORING, EVALUATION AND DISSEMINATION

A multiple level monitoring and evaluation approach will be followed while executing the project in order to ensure effectiveness. This will also help in inducting some corrective measures from time to time. The monitoring and evaluation will involve following:

- Physical progress of the work which will include
  - number of potential gasifiers identified
  - number of technological packages developed
  - number of gasifier systems installed in the field
- Performance of the gasifier systems in the field
  - Quantifying benefits from the gasifier systems
- Monitoring of gasifier system promotion mechanisms developed viz. ESCOs for after sale service, manufacturers for system quality control, marketing agency for market penetration, financial institutions for disbursement of financial assistance and its recovery, etc.
- Feedback from user target group
- GHG abatement (extent of fossil substitution and carbon sequestration)

In order to achieve this a project monitoring and coordination committee comprising representation from all stakeholders of the project will be formulated. Periodical meetings will be held to review the progress of the project and plan future courses of action.

An external agency (well-known NGO or team of experts from reputed research institutions in the field of research) will be involved to monitor and evaluate the project in terms of progress covering physical, financial as well as environmental issues. If it is found feasible and required an effort will be made to formulate a mechanism for evaluating the systems installed in the field beyond the project duration. The findings and experience gained, lessons learned from the project will be documented as case studies, which will be

made available for reference at the national as well as international level Effort will also be made to share the information and experience through workshops or seminars from time to time.

Lessons learned so far

The project is proposed based on learning and the experience of ANERT and TERI. ANERT functions under the Department of Science and Technology of the Kerala State Government. ANERT is actively involved in the dissemination of renewable energy products in the state. It has a local network of about 26-branches spread over Kerala. The existing network of ANERT will strengthen the implementation of the project. ANERT is already involved in promoting renewable energy technologies such as biogas, biomass gasification, Photovoltaic etc. This project will be an intervention to extend the activities on a large scale among the SMEs, to provide efficient and cleaner technologies. TERI has been involved in developing biomass gasifier technology since 1985. Different capacity gasifiers have been developed, covering a wide range of thermal energy input 25000 kcal/h to 750000 kcal/h. The gasifier technology for thermal applications is well established for adoption in industries, specially those using fossil fuel or fuel wood. Some MW systems are installed in the field and have been tested for technical and economical viability. The gasifiers have been tested in nine different applications, which require process heating These experiences can provide a strong technological support to ANERT for implementing the project. TERI has agreements made on technology transfer with the manufacturers and marketer to take the system to the field. TERI's experience will be used in barrier removal, ESCO formation etc.

In this exercise, the relevant ministries and government departments (e g. the Ministry of Non-conventional Energy Sources, Tamil Nadu Energy Development Agency (TEDA), and Agency for Non-conventional Energy and Rural Technology (ANERT) will be fully involved in the deliberations and formulation of the project. It is also proposed to involve SIDBI and NABARD and apex bodies of industries in the evolution of the project, as well as during the project. Furthermore, to devise a useful and workable plan, the renewable energy industry as well as the user groups will have to be involved at each stage. The involvement of industry as well as the user groups, NGOs, financial institutions (including non-banking financing companies) is ensured through workshops where issues related to gasifier-based thermal systems will be discussed and barriers to penetration of these systems will be identified and prioritized.

Table 5. Budget by Source (in '000 US$)

Cost Components	Total	GEF	MNES	Loan	State Govt.	Bilaterals	User contribution
Activity 1: Technology package standardization	880	880					
Activity 2. System Integration with process	820	820					
Activity 3. Investment risk fund	6050	100	1210	3000	600		1140
Activity 4. Information dissemination	310	310					
Activity 5. Formation of ESCOs	490	490					
Activity 6. Enhanced institutional and financial capability	2770	2770					
Sub total	11320	5370	1210	3000	600		1140

Table 6. Budget details along with activities over the Project periods (in '000 US$)

Cost Components	Years					
	1	2	3	4	5	Total
Activity 1· Technology package standardization	350	300	130	50	50	880
Activity 2. System Integration with process	320	300	120	40	40	820
Activity 3. Investment risk fund	650	1200	1200	1500	1500	6050
Activity 4. Information dissemination	50	100	60	60	40	310
Activity 5 Formation of ESCOs	150	250	90	-	-	490
Activity 6. Enhanced institutional and financial capability	850	800	550	300	270	2770
Sub total	2370	2950	2150	1950	1900	11320

Annexure A: Incremental cost

Activity	Baseline	Alternative	Incremental
1. Standardization of technology package	The existing gasifier based systems for small- scale thermal applications have low level of reliability and penetration Cost 0.0	Develop technical specifications guidelines for system design, detailed drawings, manufacturing and quality control for gasifier based technology package for specific industries. Cost US $ 880000	Higher level of reliability of biomass based gasifier system, which will increase the confidence among the user community Cost: US $ 880000
2. System integration and technology demonstration	The existing practice of use of gasifier system for thermal application is more as an retrofitting option and which result in gasifier is not being used at full of its advantage. Cost:	Develop appropriate balance of system and demonstrate the approach in target set of industries covering gasifier capacity ranging from 25,000- 7,50,000 kcal/h. Cost: US $ 820000	To demonstrate the technical viability of gasifier system for the small-scale industries sector and the supply chain mechanism including after sales service. Cost: : US $ 820000
3. Investment risk fund	No formal financing mechanism exists for investment in gasifier technology by small and medium scale industries It has been considered more risky proposition by most of the financial institute. Cost: US $ 1040000	Demonstration of the technology and effective cost recovery mechanism, it is possible to bring the confidence among the financing institutions about the technology. Cost: US $ 1140000	Increased level of investment in biomass based technology will bring much faster penetration of the technology in the field In addition all the players along the commercial supply chain will be strengthened Cost: US $ 100000

4 Information dissemination	Lack of information about the technology and ESCO model among the target group. Cost: 0.00	Increased level of awareness, capacity building of potential users, manufacturers, marketers and service providers by training workshop and other promotional materials. Cost: US $ 310000	The increased level of awareness will provide better understanding about the technology among the users. Cost: US $ 310000
5 Enhanced institutional and financial capability	In the current situation no ESCO model exists in biomass based gasifier business The low level of technical and financial capability is main bottleneck in promotion of the technology Cost 0 00	The project would address to overcome the barrier through capacity building exercise. ESCO model will be demonstrated under the project Cost: US $ 2770000	Increased level of support services network. The institutional support for the ESCO formation and business opportunity will be strengthened. Cost . US $ 2770000
6 Global benefits	The biomass based gasifier system for thermal applications are underdeveloped and hence low level of penetration despite huge potential.	Increased rate of market penetration of biomass based thermal systems in the small and medium industries as result of demonstration and promotion of ESCOs. As result of high utilisation of biomass thermal systems the saving of 305331 tons is expected over the lifetime of the systems.	C-mitigation by 305331 tc. Demonstration of ESCOs concept which could be replicated in the entire south Asian countries.

Domestic benefits	In the post liberalization period, many of the small-scale industries are facing stiff competition from cheap import due to high input energy cost. High dependence of imported fuel on meeting the low-grade thermal requirement and hence higher level of emissions.	The gasifier based thermal system has potential to reduce the energy cost considerable in many industries Encourage the new private investment in the biomass thermal system Demonstration of ESCOs model which could be replicated Lesser dependence on imported fossil fuels and hence reduction local pollution	Reduction in dependence on imported conventional fuels and hence less local pollution Leveraging of private investment in renewable energy sector

	Indicators	**Means of verification**	**Assumptions**
Goal Promotional of solar thermal technology by removing barriers, thereby reducing GHG emissions	Total capacity installed Change in fuel consumption pattern	Market surveys; indicated changes in energy consumption patterns in different sectors of economy. Reports from Industry associations & Renewable energy equipment manufacturers	Increase in installation of solar water heaters in target regions is mainly on account of the proposed project
Objective Accelerate penetration of solar thermal systems in India Reduction in CO_2 emissions as result of higher use of solar thermal systems	Increased rate of installations of solar thermal systems Increase in involvement of private players offering solar thermal systems energy Reduction in fuel/electricity consumption	Annual report from MNES/SNAs/IREDA/Independent monitoring Disbursement of loans from IREDA Requests for support from private investors to start, diversify, expand business in solar thermal Quantification of fuel consumption after the installation of solar systems	The increased installations as result of this intervention. Market infrastructure in place to fulfil the increased demand Consumption pattern of hot water/industrial process heat remains unchanged
Outcome Increased market size	Number of Solar energy services companies formed	Number of systems installed by the SESCos over years.	The acceptance of the concept of SESCo as an effective means of market penetration.

	Indicators	**Means of verification**	**Assumptions**
Increased awareness about solar thermal systems Solar energy services offered as mainstream commercial energy	Number of requests for solar thermal systems	Number of queries generated.	The attractiveness of the concept to attract private investment Long term interest of investors in the field

ANNEXURE –C: PROJECT PLANNING MATRIX

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Developmental objective (Impacts)			
The project aims to provide cleaner and efficient technology to the SMEs by intervention biomass gasification technologies. The project is designed to implement the technology, several clusters for various applications, where the scope for adopting the gasifier system is practically & economically viable	▪ Biomass fuels replaces the use of fossil fuel in case of diesel/ F.O fired boiler and increases the carbon sink ▪ By adopting the technology in case of biomass using industries ▪ The alternative technology of biomass gasification provides a cleaner environment by carbon abatement and increasing the carbon sink by conservation of trees	▪ Sustainability of the system in other industries ▪ ESCOs and marketing network establishment ▪ Replicability of the system in other industries	▪ Biomass gasification technology is one of the ideal options and there is a global commitment to reduce the GHG emissions ▪ By establishing a chain of marketing network and ESCOs the programme can be made sustainable. ▪ Adoption of the various sectors identified will lead to a remarkable reduction in GHG emission.

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Activity 1 Standardization of technology package			
Objective The biomass gasification technology is well proven for its technical and economical viabilities To adopt the technology for different application, the biomass gasifier needs a certain modification in its design with a proper technology package system integration The biomass gasifier system can be retrofitted with the conventional system to improve the efficiency, to replace the fossil fuel, and to provide a cleaner environment	▪ The existing fuel utilization pattern and the process ▪ Estimating quality measures of the product and the production rate	▪ Quality of the product ▪ Production rate ▪ Improvement in efficiency ▪ Economical benefits ▪ GHG abatement ▪ Feedback from the user	A proper technology package system is a must to integrate the alternative technology of biomass gasifier system. While retrofitting the constrains of the existing system, layout and process has to be taken into consideration.

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Design of an appropriate technology package for the gasifier system has to integrate with the existing system in the field. The system integration package will be finalized according to the performance observation obtained in the field condition The system integration will be carried out (for few systems) in each selected potential sector.	▪ Implementing the technology package prepared for system integration at each selected clusters ▪ The trained manufacturers and ESCOs will work closely with the users	▪ Verification of the system integration as per the specs drawn in technology packages ▪ Verification of the existing system package layout and capacity	▪ Through a well-designed and documented technology package and trained manufacturer in the field, ESCOs the task of the system integration in the field can be done successfully ▪ By a proper system integration, the production rate and the quality of the product can be retained as good as conventional system
Activity 2. System Integration			
Objective: to integrate the existing system with biomass gasifier system. The alternative technology has to retain the quality and production rate of the existing process	▪ Improvement in the efficiency ▪ Case of operation ▪ Quality of the product ▪ Production rate	▪ Fuel replacement ▪ Economic and environmental benefits	▪ Improvement in efficiency with alternative technology ▪ Reduction in fuel expenditures ▪ GHG abatement

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Activity 1 A detailed survey will be carried out for a selected set of industries on current energy scenario and process in each cluster	▪ Quantifying the present annual energy consumption ▪ Present process and equipment ▪ Present energy consumption pattern ▪ Quantifying the possibility and benefits	▪ Overall efficiency ▪ Specific fuel consumption rate ▪ Cost of processing ▪ Fraction of energy cost ▪ Analyzing the outcome and benefits	▪ The technology pays the investment over the life cycle ▪ There are various potential clusters to adopt the technology (PDFA)
Activity 2 Proving the viability of the technologies and the benefit to support the system replication	▪ Systematic observation and monitoring the performance of the systems in each cluster	▪ Qualifying the fuel saving, monetary benefits and GHG abatement	▪ By introducing the gasifier technology in few of the industries in each selected sectors/clusters will enhance the technology adoption.
Activity 3. Removal of barriers and credit & investment fund			
Objectivity of Activity 3: To overcome the financial barrier, to have a large scale penetration of the biomass gasification technology by creation of a "line of credit"	▪ Proposing a financing mechanism ▪ Acceptable terms and conditions for lending and recovering	▪ Financial barrier removal ▪ Market presentation ▪ GHG abatement	Involvement of financial agents (SIDBI), users, local govt , institutions, agencies and marketing network
Activity 1 Revolving fund Guidelines for operation of revolving fund, partial capital investment co-financing, pre-fixed rate of return	▪ Market penetration ▪ Sustainability of the technology adoption ▪ Regular return of EMI/EAI	▪ No of industries adopting the technology ▪ GHG abatement per annum	The technology of biomass gasifier system will be penetrating in the market at an expected rate with the proving of revolving fund concept and arrangement of ESCOs & marketing network.

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Activity 2 Guidelines for recovery mechanism To be formulated by involving the stakeholders and taking in account of CRF, IRR etc. Monitoring the recovery of revolving fund will be done periodically	▪ Qualifying the capital recovery factor and IRR ▪ Guideline formation for recovery ▪ Monitoring the recovery rate (monthly & annually basis from each sector/cluster)	▪ Analyzing the CRF & IRR ▪ Quantify the EMI ▪ Ensuring the recovery ▪ Verification of the recovery rate	Close association of stakeholders and regular return of EMI from the users Achievement of estimated CRR & IRR
Activity 3 Capital equipment financing Due to the nature of the project risks are likely to be faced in the initial stages of the projects, by the marketer and ESCOs. To mitigate the situation, a partial capital equipment financing is proposed.	▪ Partial capital financial support for manufacturer and ESCOs	▪ 20% capital by the user ▪ 30% by local govt. in terms of subsidies ▪ 50% as loan from GEF and of the Co-financiers and ESCOs	By a partial capital financial support will eliminate the risk factor and the technology can be penetrated to more set of clusters and sectors

Activity 4. Information dissemination			
Narrative summary	**Objectivity- Verifiable indicators**	**Means of verification**	**Critical assumptions**
Objective Information preparation and dissemination of, Technical details and, benefit, source of supplier, finance and the ESCOs involved operation & management system	▪ Technical specification ▪ Brochures with benefit and financing schemes ▪ Campaign designing	▪ A book with quality technical specifications ▪ Brochures on benefits and financing schemes ▪ User friendly manual for operators	▪ Installation of the system as per the project planning
Activity 1 **Awareness creation from the user:** Awareness creation among the users is an important aspect. The awareness creation will achieved by various program and methods	▪ Developing of an information package ▪ Organizing workshops, conferences and exhibitions ▪ Dissemination of leaflets and brochures highlights the merits & benefits of the system	▪ An easily understandable information package ▪ Number of awareness creation by workshop and conferences, exhibitions at various sectors & clusters ▪ Evaluating the awareness level ▪ Obtaining the feedback ▪ Monitoring the effect of awareness	By creating adequate awareness among the stakeholder, the biomass gasifier technology can be penetrated as per the estimated rate

Narrative summary	Objectivity- Verifiable indicators	Means of verification	Critical assumptions
Activity 2 **Market promotion book** Explaining the fabrication details will be prepared to support the manufacturer and marketer. This will help in delivering a quality product and service facility to the users, conducting training . program for fabricator and marketers for enhancing the market penetration	▪ Preparation of the books explaining the fabrication details, installation method and operation manual ▪ Training programs for fabricators and marketers	▪ Books on fabrication of the system with all necessary details ▪ A manual for installation ▪ An user friendly manual for operation	By providing training program and detailed books for manufacturing gasifier system will eliminate any fabrication error and can provide a quality product. The operation & maintenance manual will help the user for an easy operation of the system for over the life time
Activity 3 **Field visit to the sites** In each cluster, few systems will be integrated with the alternative technology, visits will be organized to other user and stake holders for visualizing the system performance and the ultimate benefits	▪ Selection of user ▪ System integration ▪ Performance study ▪ Data analysis ▪ Field visits	▪ Creating awareness ▪ Proving the performance and benefits ▪ Increased market penetration ▪ Feedback assessment	By integrating the gasifier system in few of the industries and organizing the field visit to show the workability and the benefit, will accelerate the market penetration process.

Activity 5 Enabling Activities			
Narrative summary	**Objectivity- Verifiable indicators**	**Means of verification**	**Critical assumptions**
Objective The project will create a favourable environment for emergence of ESCOs for facilitating the market and providing after sales service. Contract arrangement is proposed to have a negotiable on benefit recovery basis	▪ Establishing the concept of ESCOs ▪ ESCOs promotional measures ▪ ESCOs performance monitoring	▪ Establishment of adequate support from ESCOs ▪ Ensuring the smooth operation of the installed systems ▪ Market facilitation, and sustainability etc.	By formulating proper TOR and financial risk covering mechanism, effective ESCOs can be formulated to have a sustainable technology penetration
Activity Gasific technology has a huge potential for various factors of application, which is spreaded in different clusters Identifying potential clusters and establishing local ESCOs will be one of the main activities of the project. The capacity level and the number of ESCOs will be decided according to the size and benefit level of each cluster	▪ Identification of persons suitable for establishment of ESCOs ▪ Training ESCOs to install & maintain the systems (BOLT/BOOT/BOO etc) ▪ Periodic schedule for operation & maintenance of each system installed ▪ TOR formulation	▪ Arriving a certain percentage of ESCOs in each sector ▪ Basic TOR guideline and performance monitoring ▪ Summarising the findings and feedback from ESCOs	ESCOS establishment of each cluster can ensure the marketing, replication of the system installation O & M, sustainability of the market

Activity 6. Enhancing institutional capacity			
Narrative summary	**Objectivity- Verifiable indicators**	**Means of Verification**	**Critical assumptions**
It is important to create an ideal & workable institutional arrangement for implementing the project. The activities can strengthen various stakeholders through specific design of training program, workshop etc. The institution arrangement will include monitoring the performance along with the capacity building	▪ Formulating the institutional setup ▪ Drawing the responsibility of the institution at various levels ▪ Capacity building and monitoring the project outcome	▪ High level and indifferent committee members with different capacities ▪ The members covering various sectors of stakeholders ▪ Evaluating the outcome & improvement of the capacity building and training programs	▪ The proposed institutional arrangement involving technology facilitator, management expert, local govt agencies, financial institutions etc. can ensure a successful project implementation with proposed marketing network
Activity The institutional arrangement involving/including UNDP-GEF, MNES, ANERT, NGOs, ESCOs, manufacturers, marketers etc. (as per Fig.1) will be formulated with appropriate responsibility. Training programs and facilitation will be placed at each level according to the requirements. A project committee will be formulated by selecting experts from various fields of technical, economical, financial and marketing	▪ Establishment of institutional setup at various levels ▪ Drawing the guidelines and responsibility of the facilitators and institutions ▪ Planning the activity over the period of the project ▪ Planning the activity, beyond the project period ▪ Monitoring the function of the project and evaluation of the outcome during the project period and ensuring the sustainability	▪ Identification of appropriate members of the institutional arrangements ▪ Identifying the local institutions like NGOs and associations involving in the project implementation activities. ▪ Assessment of the project implementation and evaluation of the outcome	An appropriate institutional setup and the monitoring committee will ensure the implementation of the project as per planning and evaluating the outcome as per expectation/projections.